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BUREAU OF MINES
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A. U. MILLER

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UNITED STATES DEPARTMENT OF THE INTERIOR - BUREAU OF MINES

SOME INFORMATION FOR MINERS ABOUT COAL-MINE VENTILATION[1]

By A. U. Miller[2]

Adequate ventilation is one of the most important factors in the operation of a mine whether large or small. The purpose of mine ventilation is to force enough air through the mine workings to supply the requirements of underground workers and to dilute and render harmless explosive and noxious gases.

Air is a mechanical mixture of several gases. According to one authority, pure, dry air at sea level contains the following gases: Oxygen (O_2), 20.94 percent; nitrogen (N_2), 78.09 percent; carbon dioxide (CO_2), 0.03 percent; and argon (A), 0.94 percent by volume. There are also present traces of some inert gases, which are usually included with nitrogen.

Of all the gases in the air, oxygen is the most important to man because it is necessary for life and combustion. It is odorless, tasteless, and non-poisonous. Men breathe most easily and work best in air containing about 21 percent oxygen, the amount usually present in pure air. Men can work and live, but not so well, in air containing less than this amount. In air containing only 17 percent oxygen, breathing is slightly more rapid and slightly deeper; with as little as 15 percent of oxygen, breathing is much faster and deeper, workers usually become dizzy, may notice a buzzing in their ears, have a rapid heart beat, and often suffer from headache. No one is free from these symptoms when the oxygen content of air falls to 10 percent, and life is endangered when as little as 7 percent is present. Although workers usually do not lose consciousness until the oxygen content of the air drops to as low as 13 percent, no person should enter an unventilated abandoned mine or the unventilated abandoned workings of an operating mine when the oxygen content in the mine atmosphere is such that a flame safety lamp will not burn (about 16 percent oxygen) unless he is wearing self-contained oxygen breathing apparatus. This cannot be emphasized too strongly as many lives are lost each year in mines having low-oxygen atmospheres or what usually is termed "black damp."

The average man breathes 16 to 18 times per minute when at rest and inhales 24 to 42 cubic inches of air at every breath, or 300 to 780 cubic inches a minute. However, he consumes only about 18 cubic inches of oxygen a minute when at rest; but when working hard he may consume 180 cubic inches of oxygen or more per minute, and under abnormal conditions may inhale at each breath as much as 150 cubic inches.

1/ The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from Bureau of Mines Information Circular 7137."

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In circulating through a mine, normal air loses some of its oxygen by reason of the breathing of men and animals, decaying timber, and absorption by the coal. The absorbed oxygen is largely replaced by carbon dioxide. The oxygen content may be reduced also by the liberation of other gases from the coal or underlying or overlying strata. Considering the amount of oxygen necessary for the worker and the opportunities existing for depleting the oxygen content of mine air, it can be seen readily that if an adequate volume of air is not maintained at the face workings the amount of oxygen present in the mine may drop to such a degree that the health of the worker is likely to be injured and his efficiency greatly reduced.

That the oxygen content of mine air is very deficient at times is shown by air samples collected by engineers of the Bureau of Mines and analyzed by the Bureau's Gas Laboratory. Some mine-air samples taken from the return of sections where men were working have shown an oxygen content of less than 18 percent; this is entirely too low for efficiency if not for good health. The management of these mines did not know that the oxygen content of the mine air was low until these air samples were collected and analyzed; then it increased the volume of air in the sections so that the oxygen content could be maintained above 20 percent.

On the other hand, hundreds of air samples have been collected in some of the largest producing mines in the United States, employing hundreds of workers and maintaining many miles of air courses and haulageways, some of which on analysis have shown an oxygen content as high as 20.41 to 20.89 percent, which compares well with the oxygen content of normal air (20.94 percent). All of the air samples from returns of the large mines referred to showed more than 20 percent oxygen. If some of the largest producing mines in the country can maintain ventilating systems that will supply workers with air having an oxygen content very near that of normal air, surely it can be done in all coal mines. Unquestionably, the oxygen content of mine air in which men are required to work should be not less than 20 percent.

Methane (CH_4), also known as marsh gas, is produced by decay or decomposition of vegetation, or possibly by bacterial action. It is odorless, colorless, tasteless, and nonpoisonous. Methane is explosive when mixed in certain proportions with air. If 5 to 15 percent of this gas is mixed with air it will explode, the most violent explosion being produced when 10 parts of gas are mixed with 90 parts of the air. The ignition temperature of methane is about 1,100° F., and methane is lighter than air, having a specific gravity of 0.5545 (with air taken as unity). When pure, or nearly so, it is likely to be found near the roof of an enclosed space, where there is little or no air movement, such as the face of a mine room or entry or other working place, but when thoroughly mixed with air it may be found any place between the roof and floor.

Methane is liberated in virtually all coal mines, or is likely to be liberated in them, and occasionally in metal and other mines. In coal mines methane may issue from cleats or cracks in the coal, from "blowers" or "feeders," from overlying or underlying strata, and very often when irregularities in the coal, such as clay veins, "horsebacks," or faults, are penetrated. The Mine

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Safety Board of the Bureau of Mines claims that "potentially all coal mines are gassy." This is a reasonable position, as some of the many gas explosions that have occurred in the United States, and resulted in the loss of hundreds of lives occurred in mines considered nongassy, no explosive gas having been detected before or after the explosions.

The setting for almost all gas explosions in coal mines, regardless of the source of ignition, can be traced to inadequate or interrupted ventilation, lack of proper inspection, or violation of some safety rule. Either the mine did not have a volume of air coursing through the workings adequate to dilute the gas sufficiently, a door was left open, a curtain was knocked down, or the section was not examined as it should have been, permitting the accumulation of an explosive gas-air mixture to be ignited by an open light, electric arc, or some other source. This being true, if gas explosions in our mines are to be prevented in the future it will be necessary to maintain adequate ventilation and inspection, together with the strict observance of safety practices by both mine officials and employees.

Progress in ventilating coal mines, like the progress in other phases of mining, has been gradual. In the early days little or no attention was given to the quality or quantity of air, the kind of stoppings and doors, and the condition of the air courses unless the air was so bad that the men had to quit work. Some of the aged miners of today can recall working places in which they had to hang their oil lamps on a prop to keep them from "going out", and some places in which it was difficult to keep a light with a carbide lamp.

The more progressive coal companies of today are devoting more time and attention to the maintenance of efficient ventilating systems and inspection of their mines. Considerable expense is involved in maintaining an efficient ventilating system, but neglecting ventilation is likely to be much more expensive. Good ventilation makes workers healthier and more efficient and results in a reduction in accidents, while poor ventilation is very likely to make workers inefficient and dissatisfied, cause a high accident rate, and increase the cost of production. Briefly stated, good ventilation and close inspection pay large dividends to both operator and workers.

To maintain adequate ventilation in mine workings requires the cooperation of both employer and employees. The employer should install a fan capable of supplying an adequate volume of air, maintain air courses of sufficient area, install tight stoppings and doors, and maintain thorough inspection of mine workings. Workers should close doors after passing through them and if a deranged door, a broken stopping, or a line curtain out of place is observed, they should notify the boss immediately. Workers should not go into a place that has been "marked out" because of gas or other unsafe conditions until the place has been made safe; neither should they change the position of regulators after passing through them.

Miners usually are considered as being well versed in their vocation; true, they are generally well versed in the particular work they perform, but too often they are poorly informed about the mine as a whole, especially as

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regards its ventilation. Many workers, including some foremen, do not know the course of the air to the face workings even in the sections where they work, yet it certainly is not beyond the ability of underground workers to study and understand the ventilating system of the mine, including at least the direction of air flow and the splitting and distribution through the air passages, both intakes and returns. A knowledge of these simple fundamental conditions would enable each worker to understand the ventilation of the mine under normal conditions and the action it may be necessary to take under abnormal conditions, such as fires and explosions. The safest group of mine workers is that which most fully understands these problems, chief of which, as regards health and prevention of disasters, is mine ventilation. Too often, mine workers accept conditions that affect their physical condition and safety as matters of fact. It would be valuable to all concerned if greater study were given to mining problems, ventilation and otherwise, at home by individual workers or in groups such as mining classes.

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